CLAIMS

1. A semiconductor material comprising:
a silicon substrate;
a compositionally-graded transition layer formed over the silicon substrate; and
a gallium nitride material layer formed over the transition layer.

2. The semiconductor material of claim 1, wherein the composition of the transition layer is graded continuously across the thickness of the layer.

3. The semiconductor material of claim 1, wherein the composition of the transition layer is graded discontinuously across the thickness of the layer.

4. The semiconductor material of claim 1, wherein the transition layer comprises an alloy of gallium nitride selected from the group consisting of $Al_xIn_yGa_{(1-x-y)}N$, $In_yGa_{(1-y)}N$, and $Al_xGa_{(1-x)}N$.

5. The semiconductor material of claim 4, wherein the concentration of gallium in the transition layer is graded.

6. The semiconductor material of claim 4, wherein x and/or y is varied from a first value at a back surface of the transition layer to a second value at a front surface of the transition layer, wherein the back surface is closer to the substrate than the front surface.

7. The semiconductor material of claim 6, wherein the sum of the value of x and the value of y at the back surface is greater than 0.4.

8. The semiconductor material of claim 6, wherein the sum of the value of x and the value of y at the back surface is greater than 0.8.

9. The semiconductor material of claim 6, wherein the transition layer comprises $Al_xIn_{(1-x)}N$ at the back surface of the transition layer in contact with the silicon substrate.

10. The semiconductor material of claim 6, wherein the sum of the value of x and the value of y at the front surface is less than 0.3.

11. The semiconductor material of claim 6, wherein the transition layer comprises GaN at a front surface of the transition layer in contact with the gallium nitride material layer and is free of gallium at a back surface of the transition layer in contact with the substrate.

12. The semiconductor material of claim 4, wherein the transition layer comprises $Al_xGa_{(1-x)}N$.

13. The semiconductor material of claim 4, wherein the value of x decreases in a direction away from the silicon substrate.

14. The semiconductor material of claim 4, wherein the value of y remains constant across the transition layer.

15. The semiconductor material of claim 1, wherein the transition layer comprises a superlattice.

16. The semiconductor material of claim 15, wherein the superlattice includes a series of alternating $Al_xIn_yGa_{(1-x-y)}N$ and $Al_aIn_bGa_{(1-a-b)}N$ layers.

17. The semiconductor material of claim 16, wherein the of value of x, y, a, and b are constant across respective layers and the thickness of the respective layers is varied across the transition layer.

18. The semiconductor material of claim 1, wherein the transition layer has a thickness between about 0.03 micron and about 20 microns.

19. The semiconductor material of claim 1, wherein the gallium nitride material layer comprises GaN.

20. The semiconductor material of claim 1, wherein the gallium nitride material layer comprises $Al_xIn_yGa_{(1-x-y)}N$.

21. The semiconductor material of claim 1, wherein the gallium nitride material layer has a thickness of greater than 0.75 micron.

22. The semiconductor material of claim 1, wherein the semiconductor material forms a semiconductor device.

23. The semiconductor material of claim 22, wherein the semiconductor material forms an LED.

24. The semiconductor material of claim 22, wherein the semiconductor material forms a laser diode.

25. The semiconductor material of claim 22, wherein the semiconductor material forms a FET.

26. The semiconductor material of claim 1, wherein the gallium nitride material layer has a crack level of less than 0.005 $\mu m/\mu m^2$.

27. The semiconductor material of claim 1, wherein the gallium nitride material layer has a crack level of less than 0.001 $\mu m/\mu m^2$

28. The semiconductor material of claim 1, wherein the gallium nitride material layer is substantially free of cracks.

29. The semiconductor material of claim 1, wherein the gallium nitride material layer is monocrystalline.

30. The semiconductor material of claim 1, wherein the silicon substrate has a thickness of greater than 250 micron.

31. The semiconductor material of claim 1, wherein the silicon substrate is textured.

32. The semiconductor material of claim 1, further comprising an intermediate layer formed over the silicon substrate and under the transition layer.

33. The semiconductor material of claim 1, wherein the intermediate layer has a constant composition.

34. The semiconductor material of claim 1, wherein the intermediate layer comprises an alloy of gallium nitride selected from the group consisting of $Al_xIn_yGa_{(1-x-y)}N$, $In_yGa_{(1-y)}N$, and $Al_xGa_{(1-x)}N$.

35. The semiconductor material of claim 1, wherein the silicon substrate comprises a silicon wafer.

36. A semiconductor material comprising:

a silicon substrate;

a gallium nitride material layer formed over the silicon substrate, the gallium nitride material layer having a crack level of less than 0.005 $\mu m/\mu m^2$.

37. The semiconductor material of claim 36, wherein the gallium nitride material layer comprises GaN.

38. The semiconductor material of claim 36, wherein the gallium nitride material layer comprises an alloy of gallium nitride selected from the group consisting of $Al_xIn_yGa_{(1-x-y)}N$, $In_yGa_{(1-y)}N$, and $Al_xGa_{(1-x)}N$..

39. The semiconductor material of claim 36, wherein the gallium nitride material layer has a thickness of greater than 0.5 micron.

40. The semiconductor material of claim 36, wherein the gallium nitride material layer has a thickness of greater than 1.0 micron.

41. The semiconductor material of claim 36, wherein the gallium nitride material layer has a crack level of less than 0.001 $\mu m/\mu m^2$.

42. The semiconductor material of claim 36, wherein the gallium nitride material layer is substantially free of cracks.

43. The semiconductor material of claim 36, wherein the gallium nitride material layer is monocrystalline.

44. The semiconductor material of claim 36, wherein the silicon substrate comprises a silicon wafer.

45. A semiconductor structure comprising:

a silicon substrate; and

a gallium nitride material layer formed over the silicon substrate and having a thickness of greater than 0.5 micron,

wherein the semiconductor structure forms a semiconductor device.

46. The semiconductor structure of claim 45, wherein the gallium nitride material layer has a thickness of greater than 1.0 micron.

47. The semiconductor material of claim 45, wherein the silicon substrate comprises a silicon wafer.

48. The semiconductor structure of claim 45, wherein the semiconductor structure forms an LED.

49. The semiconductor structure of claim 45, wherein the semiconductor structure forms a laser diode.

50. The semiconductor structure of claim 45, wherein the semiconductor structure forms a FET.

51. The semiconductor structure of claim 45, wherein the gallium nitride material layer has a crack level of less than 0.005 $\mu m/\mu m^2$.

52. The semiconductor structure of claim 45, wherein the gallium nitride material layer has a crack level of less than 0.001 $\mu m/\mu m^2$.

53. The semiconductor structure of claim 45, wherein the gallium nitride material layer is substantially free of cracks.

54. A method of producing a semiconductor material comprising:
forming a compositionally-graded transition layer over a silicon substrate; and
forming a gallium nitride material layer over the transition layer.

55. The method of claim 54, wherein the composition of the transition layer is graded continuously across the thickness of the layer.

56. The method of claim 54, wherein the transition layer comprises an alloy of gallium nitride selected from the group consisting of $Al_xIn_yGa_{(1-x-y)}N$, $In_yGa_{(1-y)}N$, and $Al_xGa_{(1-x)}N$.

57. The method of claim 54, wherein the concentration of gallium in the transition layer is graded.

58. The method of claim 56, wherein the value of x decreases in a direction away from the silicon substrate.

59. The method of claim 56, wherein the transition layer comprises $Al_xGa_{(1-x)}N$.

60. The method of claim 54, wherein the transition layer comprises a superlattice including a series of alternating $Al_xIn_yGa_{(1-x-y)}N$ / $Al_aIn_bGa_{(1-a-b)}N$ layers.

61. The method of claim 54, wherein the gallium nitride material layer comprises GaN.

62. The method of claim 54, wherein the gallium nitride material layer comprises $Al_xIn_yGa_{(1-x-y)}N$.

63. The method of claim 54, further comprising processing the semiconductor material to form at least one semiconductor device.

64. The method of claim 54, wherein the gallium nitride material layer has a crack level of less than 0.005 $\mu m/\mu m^2$.

65. The method of claim 54, wherein the gallium nitride material layer has a crack level of less than 0.001 $\mu m/\mu m^2$.

66. The method of claim 54, wherein the gallium nitride material layer is substantially free of cracks.

67. The method of claim 54, wherein the gallium nitride material layer is monocrystalline.

68. The method of claim 54, further comprising forming an intermediate layer over the silicon substrate and under the transition layer.

69. A method of producing a semiconductor material comprising:
forming a gallium nitride material layer formed over a silicon substrate, the gallium nitride material layer having a crack level of less than 0.005 $\mu m/\mu m^2$

70. The method of claim 69, wherein the gallium nitride material layer comprises GaN.

71. The method of claim 69, wherein the gallium nitride material layer has a thickness of greater than 1.0 micron.

72. The method of claim 69, wherein the gallium nitride material layer has a crack level of less than 0.001 $\mu m/\mu m^2$.

73. The method of claim 69, wherein the gallium nitride material layer is substantially free of cracks.

74. The method of claim 69, wherein the gallium nitride material layer is monocrystalline.

75. A method of forming a semiconductor structure comprising:
forming a semiconductor structure comprising a silicon substrate, and a gallium nitride material layer formed over the silicon substrate and having a thickness of greater than 0.5 micron.

76. The method of claim 75, wherein the gallium nitride material layer has a thickness of greater than 1.0 micron.

77. The method of claim 75, wherein the gallium nitride material layer has a thickness of greater than 2.0 microns.

78. The method of claim 75, wherein the semiconductor structure forms an LED.

79. The method of claim 75, wherein the semiconductor structure forms a laser diode.

80. The method of claim 75, wherein the semiconductor structure forms a FET.

81. The method of claim 75, wherein the gallium nitride material layer has a crack level of less than 0.005 $\mu m/\mu m^2$.

82. The method of claim 75, wherein the gallium nitride material layer has a crack level of less than 0.001 $\mu m/\mu m^2$.

83. The method of claim 75, wherein the gallium nitride material layer is substantially free of cracks.

84. A semiconductor material comprising:

a silicon (100) substrate; and

a gallium nitride material layer having a Wurtzite structure formed over the silicon substrate.

85. The semiconductor material of claim 84, further comprising a compositionally-graded transition layer formed between the silicon (100) substrate and the gallium nitride material layer.